

From Sky to Detector:

X-ray Simulations with SIXTE

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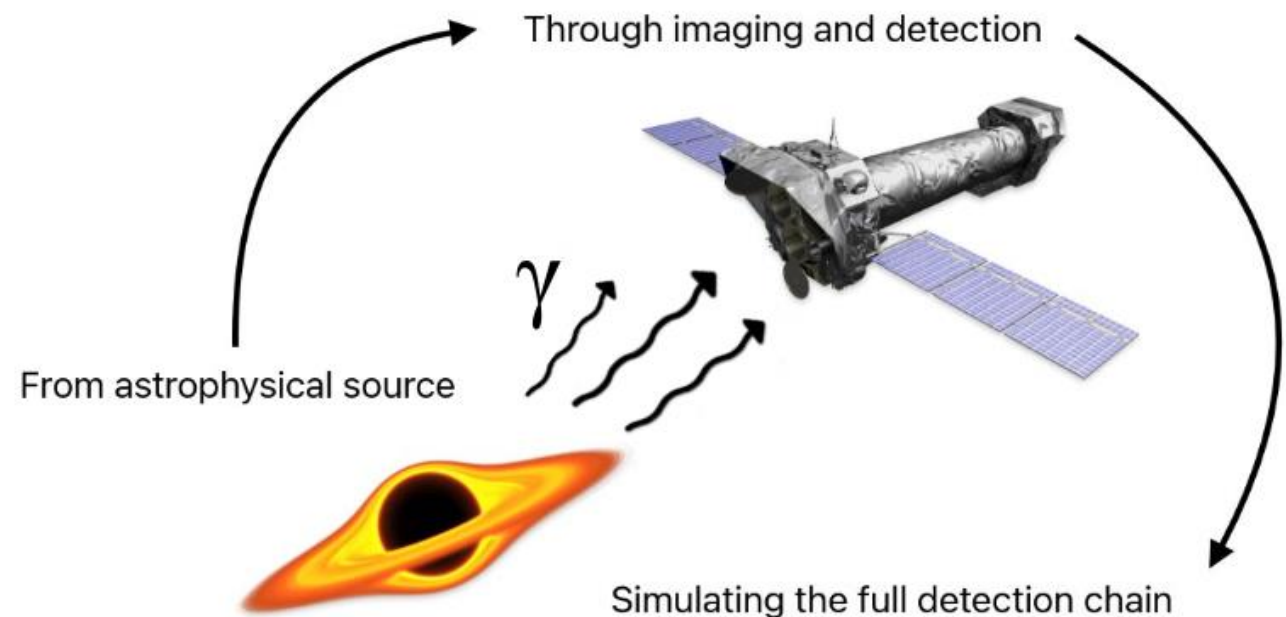
¹Dr. Karl-Remeis Sternwarte & ECAP, Friedrich-Alexander-Universität Erlangen-Nürnberg

FRANCI 2026

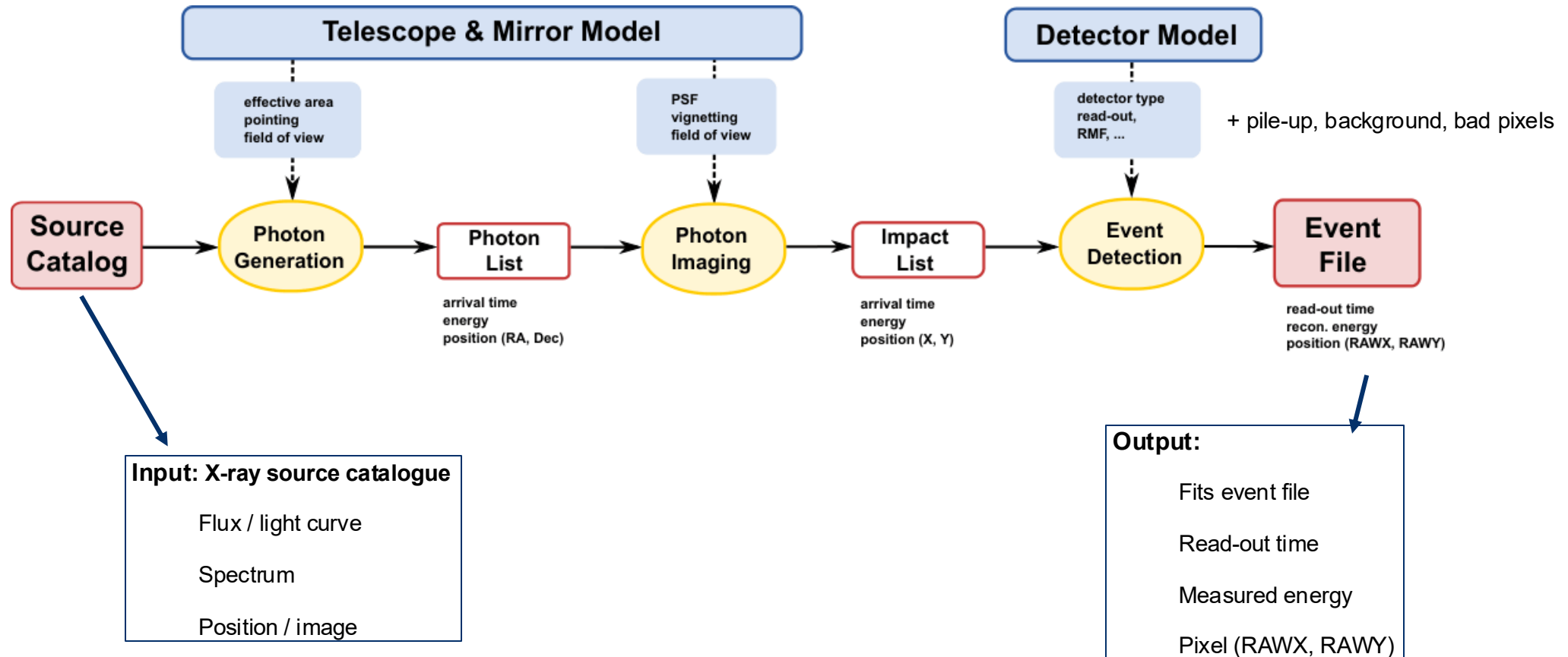
July 20, 2026

SIXTE = *Simulation of X-ray TElescopes*

- *Compromise between exactness of the simulation and speed*
- *Modular approach (easy to add new detector/physics)*
- *Study and optimize performance across science cases*
- *Support instrument and ground segment development*
- *One simulator applicable to multiple X-ray missions*

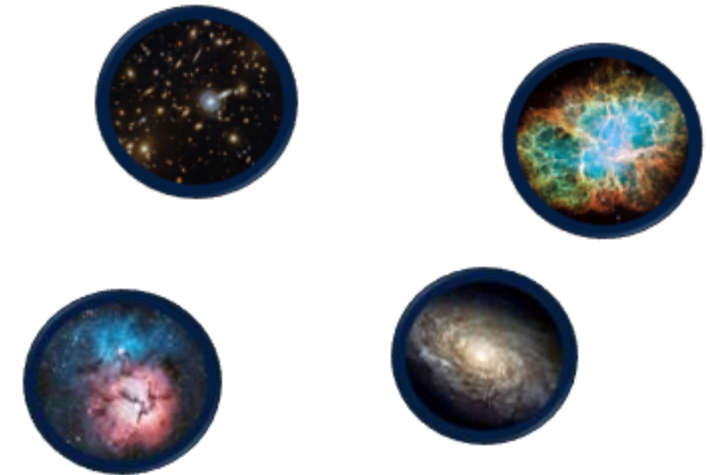


*Monte Carlo simulator **propagating single photons through the instrument**
(including possible interaction)*



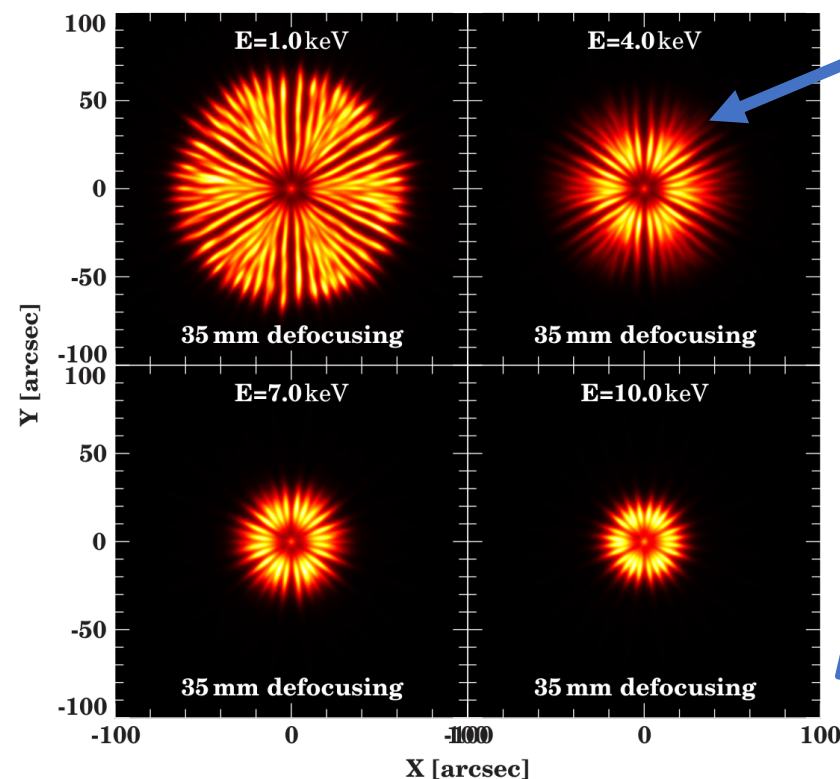
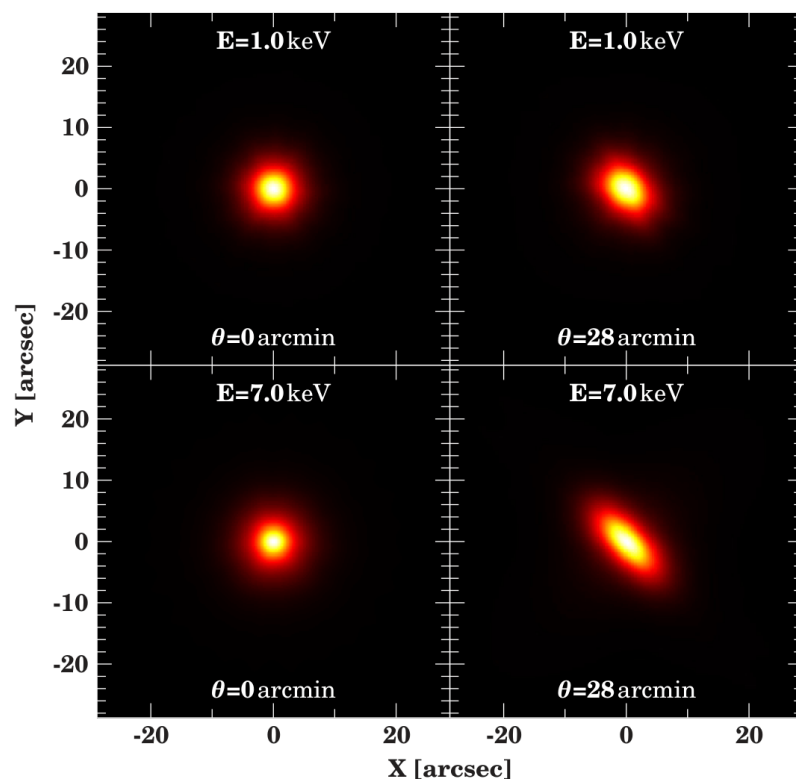
Simulation Input Format: be as close as possible to reality (no artificial limitations), independent of instrument.

You can define your
favourite source once
and simulate it with any
detector!



Photon
Imaging

- Imaging described by the PSF files of the mirrors:
 - depends on photon energy and off-axis angle (and ϕ rotation angle)*
- Ray-traced NewAthena PSF:

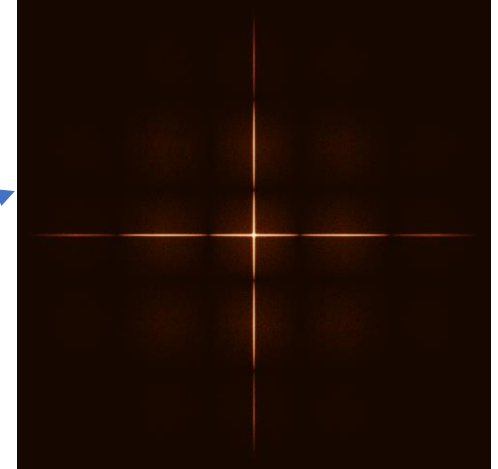


Mirror module
geometry and support
structure shadows

The simulations use
energy and off axis
dependent PSF
variations,
including defocusing.

Detector Model

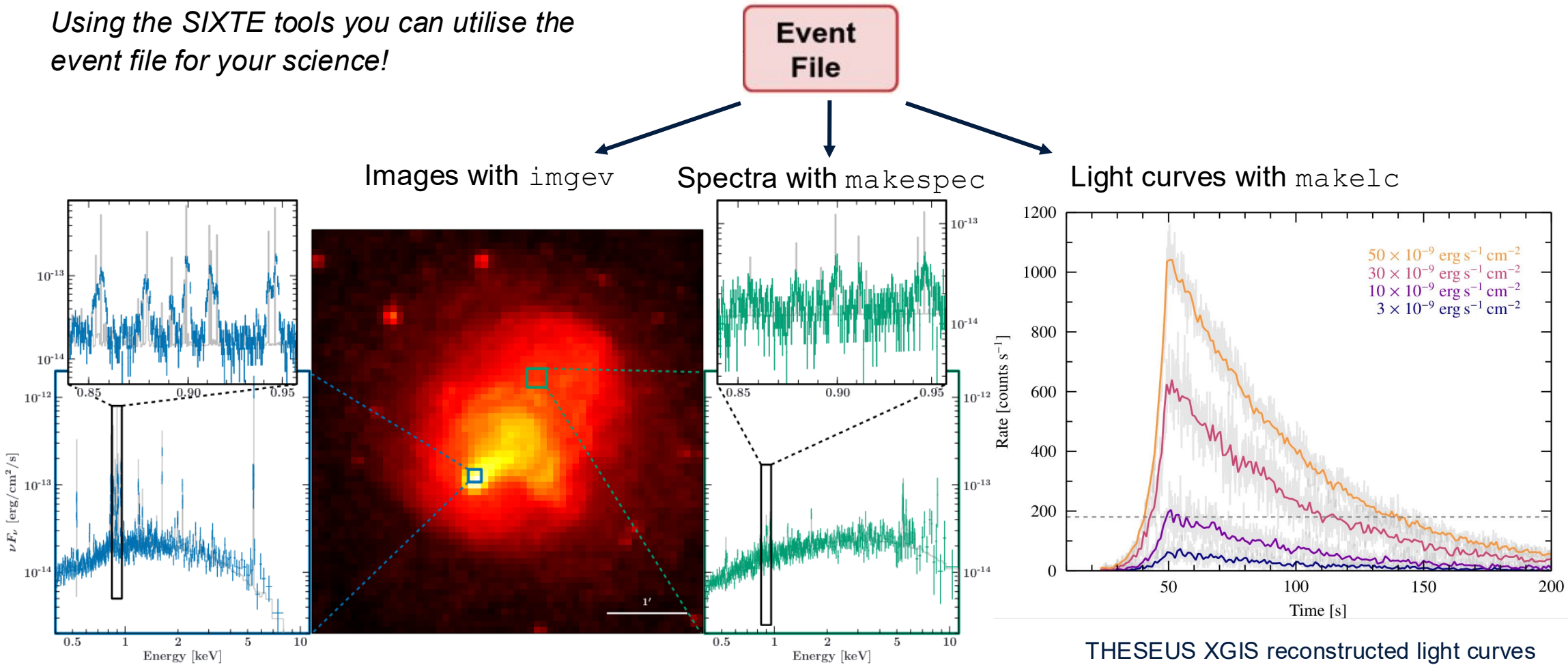
- Detection process depends on the type of detector simulated
 - DEPFET / CCD-type detectors (*e.g. NewAthena WFI, XMM, eROSITA, etc.*)
 - Calorimeter (*e.g. NewAthena X-IFU, XRISM Resolve*)
 - Lobster eye optics & coded masks (*e.g. THESEUS*)
 - Polarization (*eXTP, work in progress*)
- Various detector effects accounted for: Readout mechanics, RMF, Bad Pixels (new)



Simulation Output

FITS event files

Using the SIXTE tools you can utilise the event file for your science!



Simulation example of Abell 2146 with X-IFU
(T. Dauser/E. Pointecouteau)

THESEUS XGIS reconstructed light curves

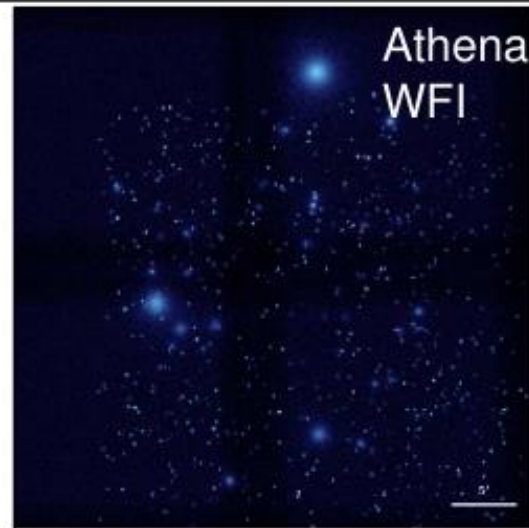
eROSITA

Athena X-IFU

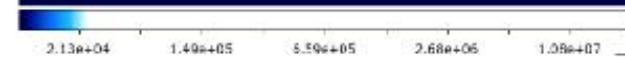
XRISM Resolve

Many types of simulations for different instruments possible:

- all-sky simulation (*eROSITA*)
- deep survey (*Athena WFI*)
- galaxy cluster (*Athena X-IFU*, *XRISM Resolve*)



Athena
WFI





Use case: to assess performance of X-ray telescopes.

SIXTE is the official end-to-end simulator for many planned X-ray missions:

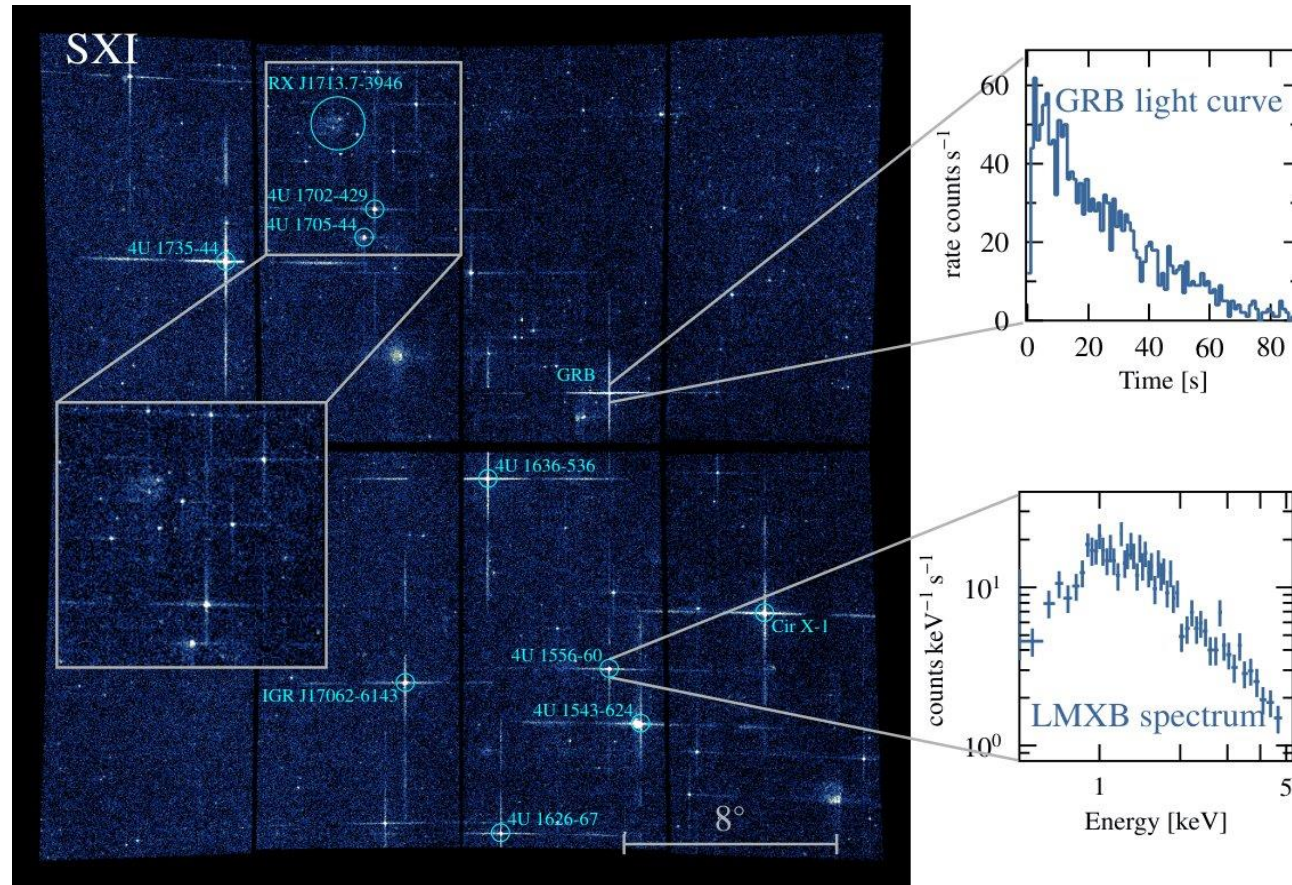
- NewAthena (*DePFET Array WFI, Microcalorimeter X-IFU*)
- THESEUS (*Lobster-Eye Telescope SXI, Coded Mask Instrument XGIS*)

For **SRG/eROSITA**, SIXTE also provided mock data for ground segment software development.

For **XMM-Newton** and **XRISM**, SIXTE is used for proposal writing.



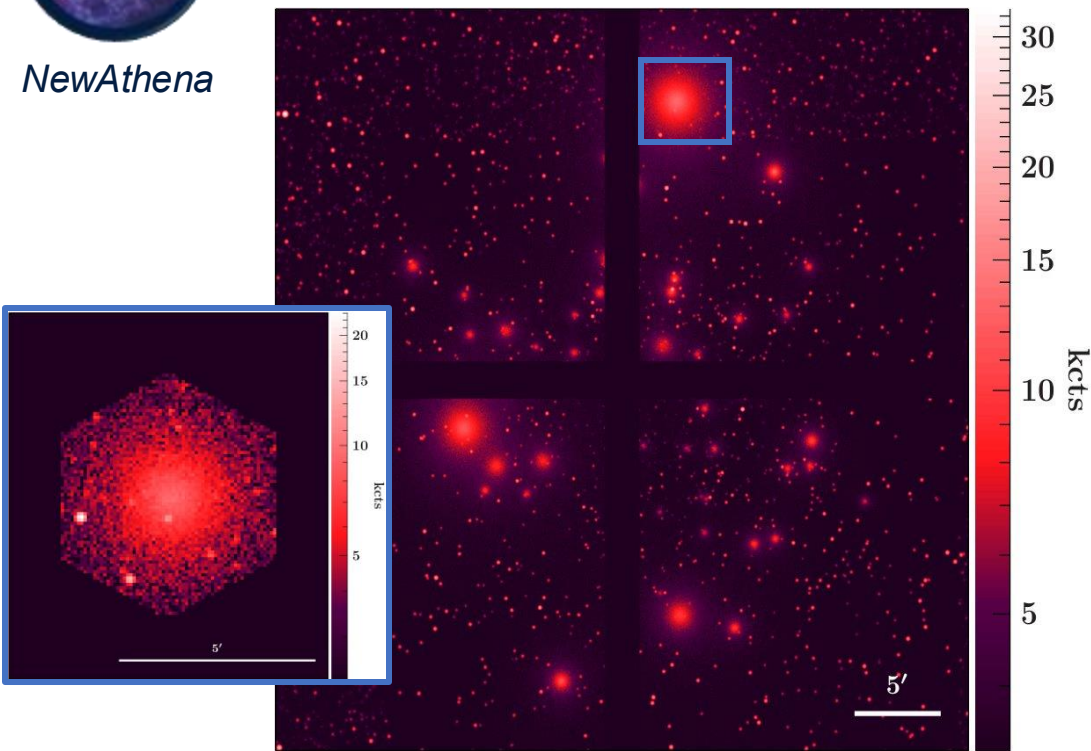
THESEUS



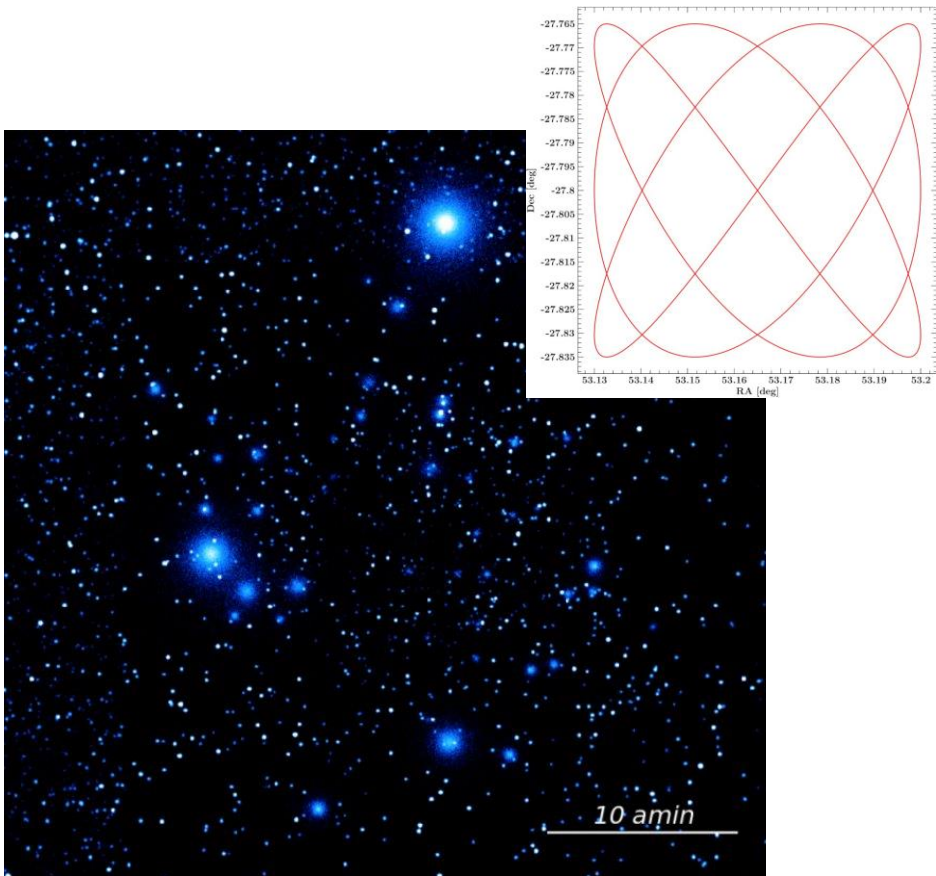
THESEUS SXI as simulated with SIXTE, Galactic Center Simulation Example



NewAthena



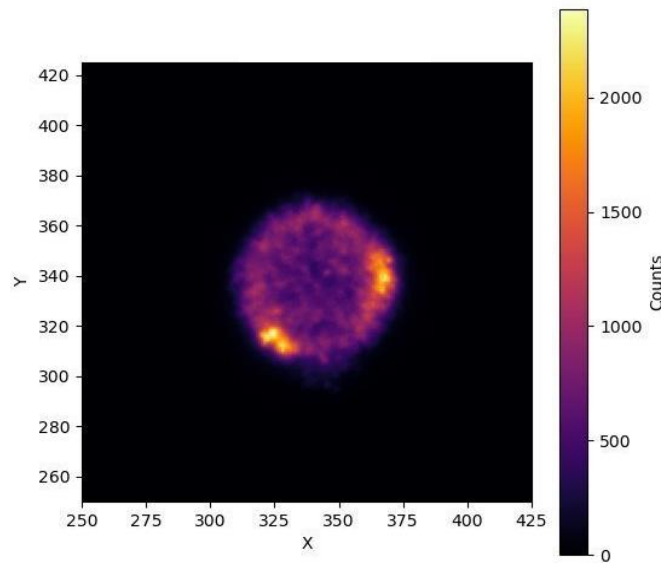
Chandra Deep Field South with NewAthena WFI



Dithering application removes the gaps between the chips.



XMM-Newton

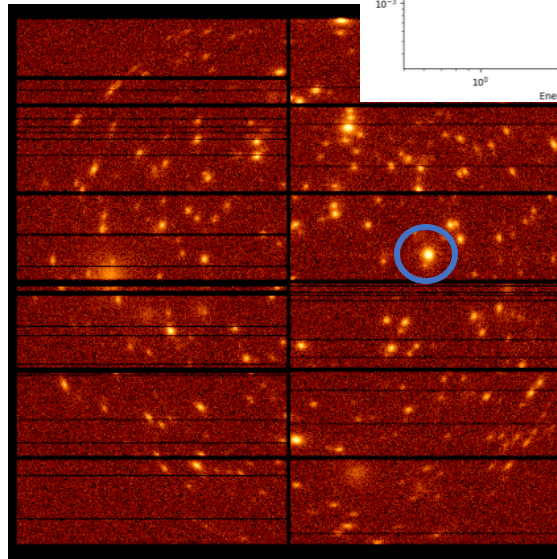
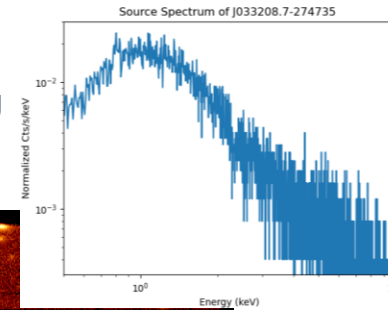


Tycho SN simulated for EPIC MOS1
Full Frame (single node) Thick
Filter

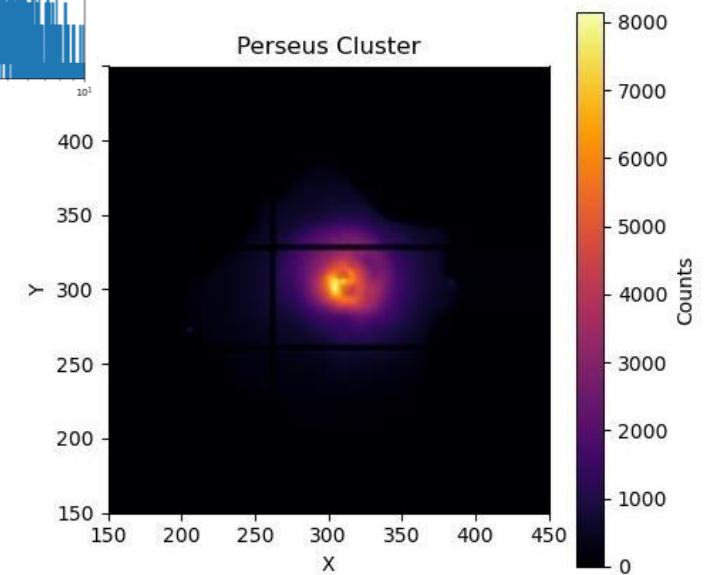
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(Quasar)

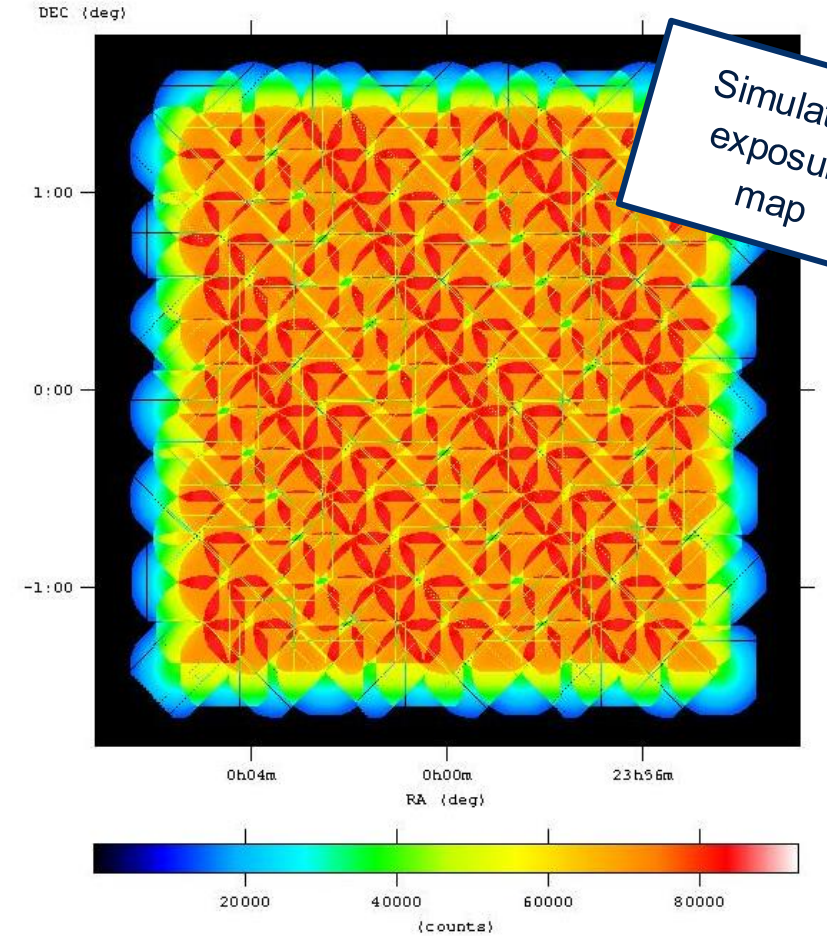
Spectrum generated using
SIXTE task makespec



Chandra Deep Field South
Simulated for EPIC-pn Full Frame
Thin Filter with Bad Pixel Masking



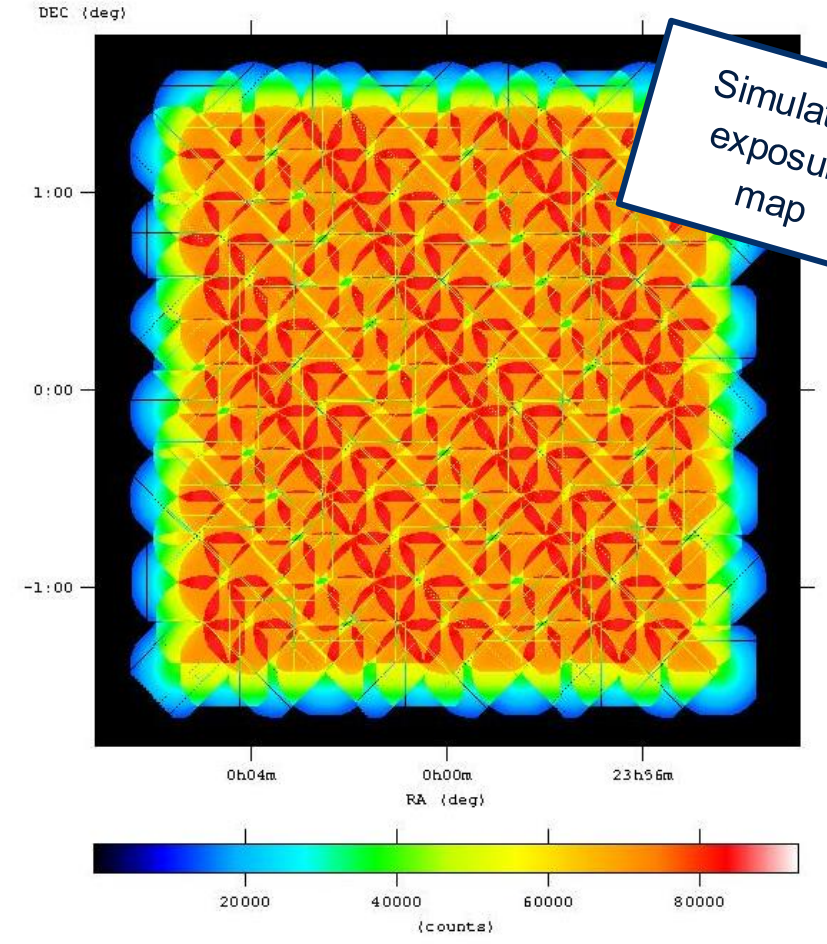
Perseus cluster simulated for EPIC-
pn Full Frame Medium Filter



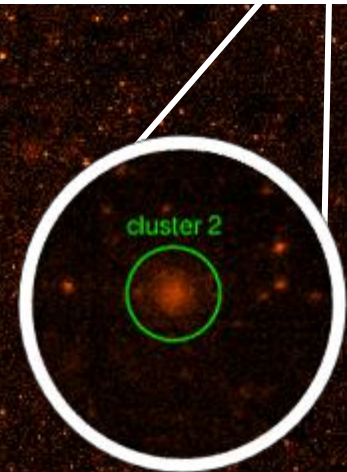
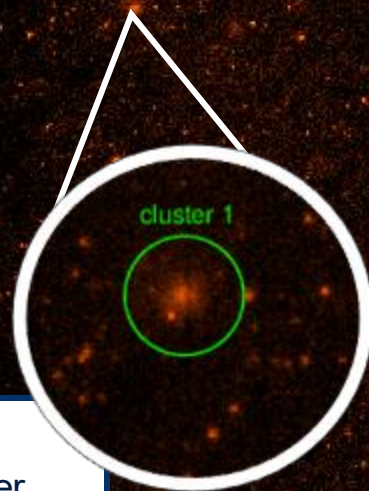
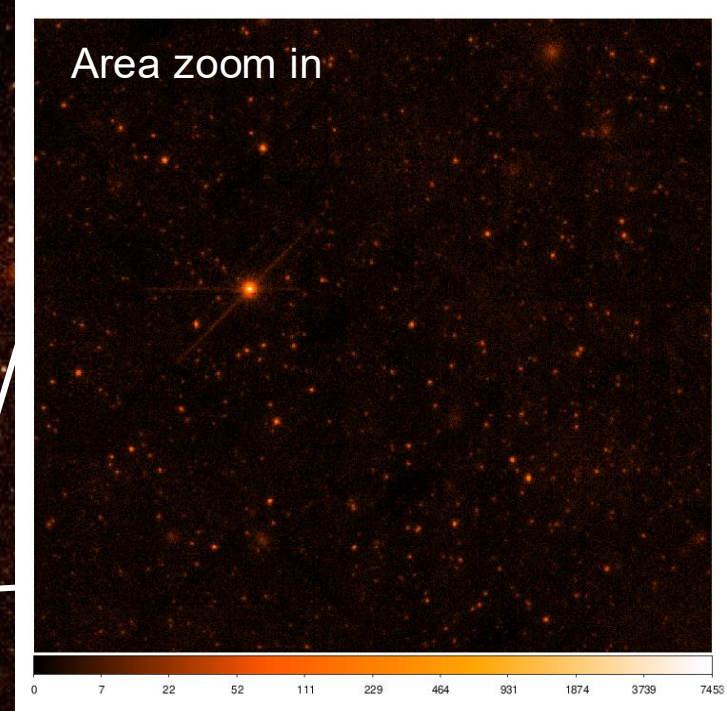
Example 10deg² field mosaic XMM-Newton observation simulation with SIXTE for FF Thin Filter EPIC-pn

- 40ks exposure
- Total 161 observation tiles
- Roll angle cycled through 0°, 45°, 90°, 135°
- Pointing moved by 15'

SIMPOT of AGN and
Galaxy Clusters



Simulation
exposure
map



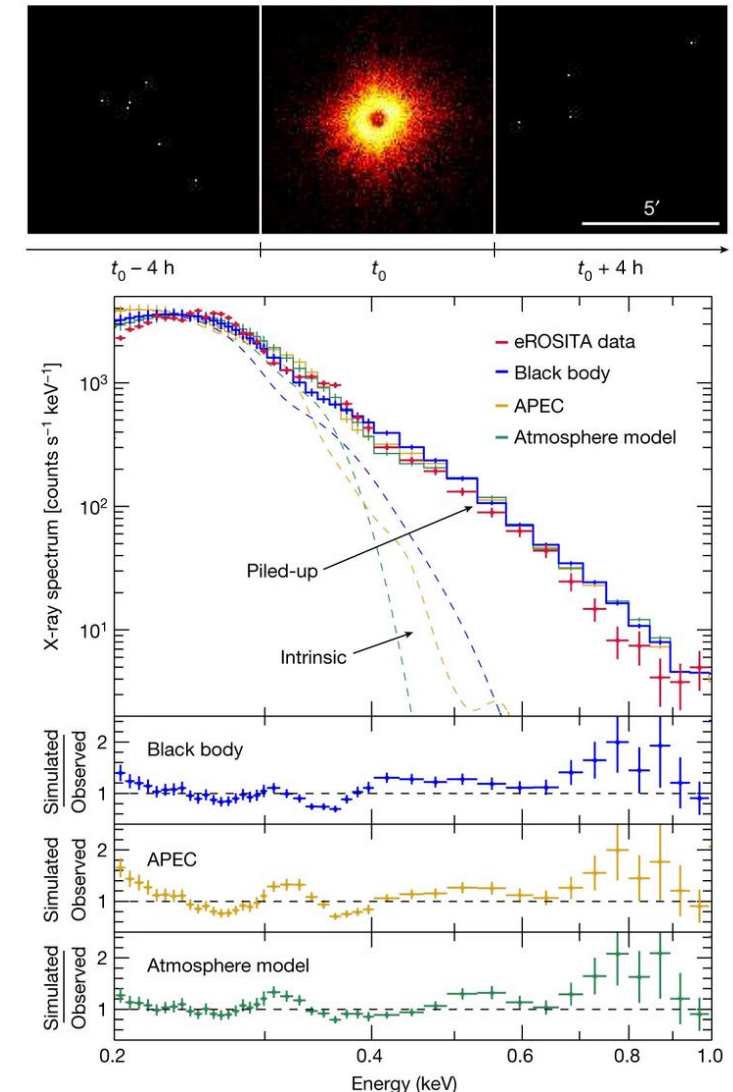
Example 10deg² field mosaic XMM-Newton
observation simulation with SIXTE for FF Thin Filter
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Science use case example

See X-ray detection of a nova in the fireball phase by König et al. 2022

- Using SIXTE to simulate and correct the detector's response to measure the nova's real physical properties, even though the observation was affected by extreme pile-up.





- **Installation, instrument files, and tutorials:**

- <https://www.sternwarte.uni-erlangen.de/sixte/>
- Also via **SciServer** and **DockerHub** (*fausixte*)

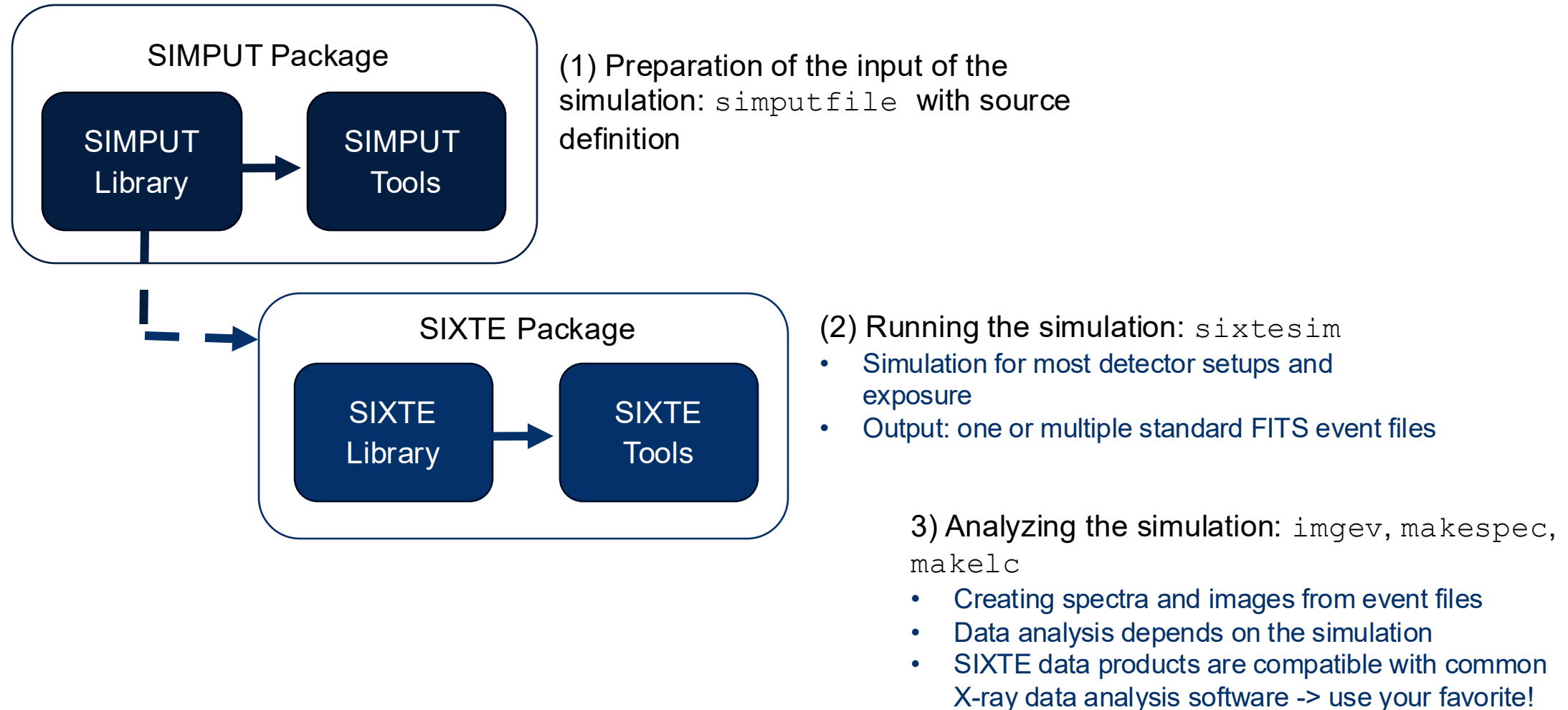
- **Helpdesk:** sixte-support@lists.fau.de

- **Mailing list:** sixte-users@lists.fau.de

- **Further information:**

- *Dauser et al. (2019, A&A 630, A66)*
- *The SIXTE manual*

Thank you for the
attention! :)



⇒ You will need both SIMPUT and SIXTE